INTRODUCTION

Cycling is a sport that demands the compromising relationship between man and machine in order to be successful. Performance is dependent on a number of environmental, mechanical, and human factors. It is well known that environmental factors are critical to effective power production and movement. These include wind resistance, rolling resistance, and friction within the machinery itself. Engineers have focused extensively on designs and developments of lighter, more aerodynamic bicycles to confront these issues while often overlooking the human component of cycling performance.

Cycling is a sport that demands the most out of the rider and bike together in order to perform optimally. Power and efficiency are the two most important factors when riding a bike. In cycling, power and efficiency are uniquely determined by the four design parameters; pelvic inclination, crank length, seat height and rate of crank rotation (Gregor et al., 1991; Too, 1990; Yoshiyuku and Herzog, 1990). Yoshihuku and Herzog (1990) developed an optimization model explaining how power transfer could be optimized by tailoring the bicycle equipment to the individual.

Specifically, a cleat and pedal system utilizing a heel position (HP) as the point of transfer of power rather than the traditional toe position (TP) may help improve power output and pedaling efficiency. This arrangement may assist the cyclist keep his/her heels down during the recovery phase of the pedal stroke, thus achieving a more even distribution of force to the pedals. The purpose of this study was to examine the effects of altering cleat placement on the bottom of a cycling shoe on peak power outputs, pedaling efficiency and ankle angle.

METHODS

Ten competitive male cyclists participated in this study. Competitive ‘status’ was determined by minimum requirements in mileage/week, hours/week, years racing, and the number of races per year they competed in and or their category ranking (Category 5 or higher) based on United States of America Cycling Federation. The subjects’ characteristics (mean ± SD) were age 32.5 ± 11.2 yrs, mass 73.7 ± 8.5 kg, and height 179.4 ± 5.2 cm. Each subject completed two different tests using the Computrainer (CT) per cleat position.

Testing Protocol: The first visit served as a familiarization session and was used to determine the subjects’ anthropometrics, bike geometry, and to serve as a practice session using the CT system and software, along with becoming familiar with the shoes and cleat positions. The second session took place 1-3 days after the familiarization session and served as the data collection session in which two tests were performed.
for each of the two cleat positions; Modified Wingate (MWgat) for Peak Power Output (PP) and SpinScan (SS) for pedal efficiency. The order for testing between the TP and HP conditions was randomized.

The pedaling rate for the spin scan (SS) was set at 90 rpm. The protocol for the MWgat consisted of a 55 second steady state ride at 100 W. The gearing was predetermined and consistent for all trials. The load was determined for each subject based on 9 watts/kg body weight. Kinematic data were collected using a 60 Hz digital video camera, during the SS testing sessions only, in order to determine the effects of the two cleat positions on the ankling patterns. The mean ankle angles for the four phases (0-90, 90-180, 180-270, 270-360) were calculated for one complete pedal revolution. The Statistics Package for the Social Sciences (SPSS) was used to perform a one-way ANOVA for the ankle angles among participants between conditions. A paired-sample t-test was used for the analysis of the peak power outputs and pedal efficiencies.

RESULTS AND DISCUSSION

Peak Power Output (MWgat) – There was no significant difference (p = .820) between PP outputs during the two cleat conditions. The mean values were 666.11 W and 661.77 W for the TP and HP respectively. Pedaling Efficiency (SS) – The results obtained from the CT during the SS, however, did indicate a significant difference (p = .027) between average TP (73.4) and HP (77.0) pedal efficiencies.

Ankle Kinematics - The mean ankle angle was calculated for the entire stroke resulting in angles of 82 ± 4.3 and 79.9 ± 2.5 for the HP and TP respectively. A break down of the pedal stroke into 4 quadrants did illustrate a significant difference in the first half of the power phase and second half of the recovery phase seen in Table 1.

<table>
<thead>
<tr>
<th>Ankle Angles</th>
<th>Toe</th>
<th>Heel</th>
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<tbody>
<tr>
<td>0-90</td>
<td>87.06 (0.93)</td>
<td>82.79 (0.84)*</td>
</tr>
<tr>
<td>90-180</td>
<td>77.98 (2.87)</td>
<td>77.38 (1.46)</td>
</tr>
<tr>
<td>180-270</td>
<td>78.83 (1.62)</td>
<td>78.01 (0.79)</td>
</tr>
<tr>
<td>270-360</td>
<td>83.84 (1.46)</td>
<td>80.9 (1.11)*</td>
</tr>
</tbody>
</table>

Table 1: Mean ankle angles (±SD) for the four phases of the pedal stroke.

The purpose of this study was to examine the effects of altering cleat placement on the bottom of a cycling shoe on PP outputs, pedal efficiency mechanics and ankle joint angles. Placing cleats on the heel of the shoe alters the lower body kinematics during the pedal stroke which potentially affects the efficiency during cycling.

SUMMARY/CONCLUSIONS

The results of this study indicate that while there was no significant difference in PP outputs between cleat positions, a smoother pedaling pattern does exist when using the HP position. This results in a more evenly displaced pattern of force production through the complete 360 degrees of the pedal cycle. Future studies should examine the long term effects of training with the HP cleat position on power output and muscle activation patterns.

REFERENCES

